## Question 38: How does coke morphology vary with changes in feed quality? What feed tests do you require to quantify the impact on coke quality?

**MICHAEL KIMBRELL** (Becht Engineering)

Predicting coke morphology from feed properties has not been 100% successful as the Coker operating conditions can make a difference if the feed is close to the shot coke vs. sponge coke threshold. The traditional approach uses the asphaltene content of the feed divided by the concarbon value of the feed. For ratios less than 0.35 asphaltene/concarbon, the coke morphology is typically sponging coke. When that ratio is above about 0.60, the coke morphology is typically shot coke. In-between these two values the coke produced is a mixed morphology which is sometimes called bonded shot coke or transition coke. An approach that includes the operating conditions is to divide the asphaltene content by the coke yield as a percent of the fresh feed. Values of less than 0.30 are typically sponge coke while values higher than this are typically shot coke.

Part of the reason that these metrics are not more accurate is that they are not addressing the actual mechanism for shot coke production. My understanding of the mechanism is that shot coke is produced when the asphaltenes form a separate liquid phase in the Coker feed. These asphaltenes are dispersed in the rest of the resid matrix as small droplets which coke at a higher rate than the rest of the resid. If the resid matrix begins to coke without forming a separate liquid phase, then sponge coke is produced. Adding FCC slurry oil to Coker feed will prevent shot coke formation as the slurry oil is very aromatic and will keep the asphaltenes dissolved in the resid until coke begins to form. Understanding asphaltene solubility in the various Coker feeds is the key to accurately predicting coke morphology based on feed properties and Coker operating conditions.

Blending feeds, either crude oils or resids, together to reach a specific asphaltene to concarbon ratio to stay in the sponge coke regime has not been completely successful, particularly when multiple feeds are blended together. This is understandable when the mechanism of shot coke formation is asphaltene solubility and not just the total quantity of asphaltenes. These simplified metrics are successful at the extreme ends of the ranges and less successful as the solubility threshold is approached from either direction.

**EZEQUIEL VINCENT** (KBC)

Micro Carbon Residue (MCR) or Conradson Carbon Residue (CCR) tests are carried out to determine the amount of carbonaceous residue formed after evaporation or pyrolysis of the coker feed. Then, a ratio of MCR or CCR to asphaltene content is calculated to try and predict which type of coke will be formed. If CCR/Asphaltene is greater than 2, then shot coke will be formed, below that number, it is very likely that sponge coke will be formed.

Metals in feed can also be used as a good indicator on the size of the asphaltenes in the Coker feed. Finally, the API of the Coker feed is another validation of the type of the coke to be produced (API>8 will not generate shot coke while API<5 will generate shot coke; API between 5 and 8 is considered a “grey” area).

Petroleum Coke is marketed based on quality and it is highly dependent of the Coker feed quality. The coke quality is mainly defined by sulfur and metals content. Coke with a low sulfur content (<4 wt%) and low metals content (<500wppm), is typically marketed as incremental anode grade coke. Coke with high sulfur content is marketed as fuel grade coke with deceasing value when the sulfur level is higher.

Highly aromatic feedstocks (as from FCC slurries or heavy waste streams coming from the FCC) will form needle-type coke.

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